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Indian Standard

SPECIFICATION FOR DIRECT RECORDING ELECTRICAL MEASURING INSTRUMENTS

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110 002

Gr 9 *March* 1972

Indian Standard
SPECIFICATION FOR DIRECT RECORDING ELECTRICAL MEASURING INSTRUMENTS

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Indian Standard
SPECIFICATION FOR DIRECT RECORDING ELECTRICAL MEASURING INSTRUMENTS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 21 June 1971, after the draft finalized by the Electrical Instruments Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 In this standard the concept of error is limited to those errors determined when the apparatus is under reference conditions. This concept of error is concerned with the intrinsic qualities of the instrument, in contradistinction to the variation in recording which may arise from the use of the instrument under conditions other than the reference conditions. The term ' intrinsic error ' is used to avoid confusion between these.

Note — For explanation of this concept, reference may be made to Appendix B of IS : 1248-1968*.

The errors and variations in connection with the measured quantity are due to the measuring element. The nature of the effect of friction (if any) of the marking device on the chart differs from that of the errors and variations due to the measuring element. This effect is subject to separate definitions and requirements (*see* **2.6.5** and **10.5**).

0.3 Quantities which influence the errors of instruments are:

a) temperature,
b) position of instrument,
c) external magnetic induction,
d) panel (ferromagnetic or conductive),
e) frequency,
f) wave form of ac supply,
g) ripple content of dc supply,
h) chart,
j) quantity of ink,
k) quality of ink,

---

*Specification for direct acting electrical indicating instruments (*first revision*).

m) supply voltage, and

n) electrostatic field.

The reference conditions of these influence quantities have been specified for determining errors in this standard.

0.4 The environmental tests specified in this standard are dry heat, dry cold and damp heat (cycling) tests. It is however recognized that for instruments used in special cases (for example, defence), other environmental tests may also be necessary. In such cases it is recommended that the additional requirements should be separately specified.

0.5 This standard is one of a series of Indian Standards on electrical instruments.

0.6 In the preparation of this standard, assistance has been derived from the following:

IEC Publication 258-1968 Direct recording electrical measuring instruments and their accessories (first edition). International Electrotechnical Commission.

DIN 43831-1962 Recording instruments for panel flush mounting, dimensions of cases and characteristics. Deutscher Normenausschuss.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard applies to direct recording and direct recording-cum-indicating electrical measuring instruments both the continuous line and the dotted line types, which are used for recording or recording-cum-indicating the instantaneous, rms or mean values of one or more measured quantities as a function of time. It refers to strip, drum and disc recording instruments, namely:

a) ammeters,

b) voltmeters,

c) wattmeters, varmeters and phasemeters (single and poly-phase),

d) frequency meters, and

e) ohm-meters.

---

*Rules for rounding off numerical values (*revised*).

This applies to those instruments which incorporate rectifiers or diodes and to thermocouple instruments, also to certain accessories like shunts, series resistors, inductors and capacitors, used with such apparatus.

In the case of other accessories associated with instruments in as much as the calibration has been made of the instrument together with the accessory, the standard is applicable to the combination of instruments and accessory.

1.2 The standard also applies to electrically measuring equipment provided that the recording electrically measuring instrument (receiver) only is considered, and that the relationship between the non-electrical quantity to the electrical one is known.

(Furthermore, it applies to recording instruments incorporating electronic devices in their auxiliary circuits).

1.3 This standard does not apply to:

a) recording instruments having a square wave response greater than 90 percent on a square wave with an amplitude equal to the effective range and frequency of 5 Hz,
b) recording instruments incorporating, in their measuring circuits, amplifying or electronic devices (other than rectifiers or diodes),
c) integrating recording instruments, and
d) indirect recording instruments.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions in addition to those given in IS : 1885 (Part XI)-1966* and IS : 1248-1968† shall apply.

2.1 General

2.1.1 *Measuring Circuit* — The electrical circuit which, when energized by a voltage (voltage circuit) or a current (current circuit), produces either alone, or in conjunction with another circuit, the deflection of the moving element of the instrument.

2.1.2 *Auxiliary Circuit* — Circuit other than the measuring circuit(s), required for the operation of the instrument.

2.1.3 *Response Time (of a Continuous Line Recording Instrument)* — The time taken by the marking device and pointer (if incorporated) to reach 90 percent of the final steady deflection after the sudden application of the measured quantity.

---

*Electrotechnical vocabulary: Part XI Electrical measurements.

†Specification for direct acting electrical indicating instruments (*first revision*).

2.1.3.1 *Slow response* — Response time more than 2·5 seconds.

2.1.3.2 *Fast response* — Response time 2·5 seconds and less.

2.1.4 *Frequency Response (of a Continuous Line Recording Instrument)* — The frequency range(s) of a sinusoidally varying quantity to which the instrument will respond within specified limits (amplitude and/or phase) and give a clear marking of the measured quantity.

2.1.5 *Square Wave Response (of a Continuous Line Recording Instrument)* — The frequency range of a square wave quantity for which the instrument gives a record the maximum values of which lie within specified limits.

2.1.6 *Square Wave* — Waveform of a quantity successively assuming two different values which are kept constant during equal time intervals, the duration of the change being negligible against these intervals. The two values may or may not have the same polarity or one of them may be zero.

2.1.7 *Damping Time* — The time taken by the marking device to reach and remain within a specified band about its final position after the sudden application of the measured quantity.

2.1.8 *Cycle Time (for a Multipoint Recording Instrument)* — The time taken to complete one cycle of marking or printing in case of recording of more than one measured quantity as a function of time.

2.2 Description of Recording Instruments

2.2.1 *According to the Recording Mechanism*

2.2.1.1 *Direct recording instrument* — A recording instrument in which the marking device is mechanically connected to the moving element of the measuring mechanism and actuated thereby.

2.2.1.2 *Indirect recording instrument* — A recording instrument in which the marking device is driven by a motor or other device electromechanically or electronically controlled by the measured quantity.

2.2.1.3 *Integrating recording instrument* — An instrument which records the integral of a quantity over a definite period of time.

2.2.2 *According to the Ordinates of the Chart*

2.2.2.1 *Instrument with rectilinear ordinates* — A recording instrument in which the marking device records a practically straight line, when the chart-driving mechanism is inoperative and the measured quantity is changed.

2.2.2.2 *Instrument with curvilinear ordinates* — A recording instrument in which the marking device records a curve, when the chart-driving mechanism is inoperative and the measured quantity is changed, 2.2.3 *According to the Type of Chart*

2.2.3.1 *Strip chart recording instrument* — A recording instrument in which the chart is a strip driven as a function of time by the chart-driving mechanism, the chart being automatically stored, for example, on a spool or emerging from the instrument case through a slot.

2.2.3.2 *Drum recording instrument* — A recording instrument in which the chart is wrapped as a single turn around a cylindrical drum, driven as a function of time by the chart-driving mechanism.

2.2.3.3 *Disc recording instrument* — A recording instrument in which the chart is a disc driven as a function of time by the chart-driving mechanism.

2.2.4 *According to the Method of Marking*

2.2.4.1 *Recording instrument with marking device in direct contact with the chart* — A recording instrument in which the record is affected by a device in direct contact with the chart, for example, a pen or stylus recording instrument.

2.2.4.2 *Recording instrument with marking device not in direct contact with the chart* — A recording instrument in which the record is affected by a device not in direct contact with the chart, for example, a light ray.

2.3 Characteristic Features

2.3.1 *Mechanism*

2.3.1.1 *Marking device* — That part of a recording instrument which records on the chart the value of the measured quantity.

It may be according to the method and kind of marking, that is:

a) a pen associated with an ink well (if any),

b) a stylus associated with a power supply (if any),

c) a printing device associated with an inking ribbon(s) or thread(s),

d) any other device performing this function, or

e) number of marking points, such as 1, 2, 3, 6 and 12.

2.3.1.2 *Chart-driving mechanism* — A mechanism for driving the chart as a function of time. This mechanism may be operated by one of the following:

a) Spring-driven hand-wound clockwork,

b) Spring-driven electrically wound clockwork,

c) Synchronous self-starting motor without running reserve,

d) Synchronous self-starting motor with running reserve, or

e) Impulse-driven motor.

2.3.2 *Chart and Record*

2.3.2.1 *Chart* — A strip or disc provided with printed lines with or without figures, from which are obtained the values of the measured quantity as a function of time, possibly by means of a reading rule.

2.3.2.2 *Record* — The. curve traced on the chart by the marking device of the instrument.

2.3.2.3 *Chart lines* — A series of printed lines on the chart which enables the record to be interpreted. There may be two series of chart lines:

a) *Chart scale lines*
   1) The lines by means of which percentage value of each recorded quantity is read, such as in linear charts.
   2) The lines by means of which the value of the measured quantity is read, such as in the calibrated charts.

b) *Chart time lines* — The lines by means of which the time for each value is read.

2.3.2.4 *Chart division* — The interval between the two consecutive chart lines.

2.3.2.5 *Chart numbering* — The series of numbers designating the chart lines.

2.3.3 *Fiducial Value* — A value to which reference is made in order to specify the accuracy of an instrument:

a) When the mechanical zero is on one extreme chart scale line or is outside the extreme chart scale lines, the fiducial value corresponds to the upper limit of the effective range.

b) When the mechanical zero is displaced within the two extreme chart scale lines, the fiducial value is equal to the sum of the absolute electrical values corresponding to the two limits of the effective range.

c) For frequency recorders the fiducial value corresponds to the upper limit of the effective range.

d) For phasemeters, the fiducial value corresponds to 90 electrical degrees.

2.3.4 *Mechanical Zero* — The equilibrium position which the index will approach when a mechanically controlled measuring element is de-energized. This position may or may not coincide with the zero chart scale line.

NOTE — In recording instruments without mechanical control, there is no mechanical zero and this position is indeterminate. In mechanical suppressed zero instruments, the mechanical zero does not correspond to any chart scale line.

2.3.5 *Device for Time Setting of the Chart* — The device which enables the chart to be moved when necessary so that the marking device corresponds to the appropriate chart time line.

2.4 Ratings

2.4.1 *Rated Chart Speed (Linear or Rotary)* — The value(s) of the chart speed assigned by the manufacturer.

2.4.2 *Rated Values of Voltage and Frequency of the Auxiliary Supply of the Chart-Driving Mechanism* — The value(s) assigned by the manufacturer, of the voltage and frequency of the supply to the auxiliary circuits for the chart-driving mechanism.

2.4.3 *Rated Upper Limit of the Frequency Response* — The upper limit of the frequency response, in hertz, at which the recorded peak value of a sinusoidally varying quantity does not differ by more than 10 percent from the exact peak value (*see* **10.6.6**).

2.4.4 *Rated Running Time of the Chart-Driving Mechanism* — The running time, assigned by the manufacturer for spring-driven clockwork and for running reserve, to which the requirements of this standard are related (*see* **7.1.5**).

2.4.5 *Rated Values Necessary for Correct Operation of the Marking Device* — Values assigned by the manufacturer for:

a) the supply voltage for the marking device, and

b) the supply voltage for the light source (if any).

2.5 Influence Quantities and Reference Conditions

2.5.1 *Influence Quantity* — One of the quantities which affect the recording of an instrument, but which is not the one measured by the instrument.

NOTE — Friction of the marking device on the chart (*see* **2.6.5** and Appendix **C**) is not considered an influence quantity.

2.5.2 *Nominal Range of Use* — A range of values assigned by the manufacturer which an influence quantity may assume without the recording of the instrument changing by amounts in excess of those specified in **8**.

2.5.3 *Total Running Time of the Chart-Driving Mechanism* — In the case of spring-driven clockwork, that time, specified by the manufacturer which exceeds the rated running time and to which are related the requirements of **8.1.8.3**.

2.5.4 *Reference Chart* — The charts to which the errors of instruments are referred, and the characteristics of which (perforations, disposition of lines, etc) conform with those assigned by the manufacturer.

2.5.5 *Reference Reading Rule (if any)* — Numbered rule supplied with the instrument and used for reading the recordings of the marking device on the chart.

2.6 Errors and Variations of Recording Instruments

2.6.1 *Absolute Error* — The measured value of a quantity minus its true value, expressed algebraically.

In the case of time, the absolute error is the difference between the duration corresponding to the chart travel between the recordings of two specific events and the true time which has elapsed between the two events.

2.6.2 *Relative Error* — The ratio of the absolute error to the true value of the quantity that is being measured.

In the case of time, it is the ratio of the absolute error to the true value of time.

2.6.3 *Variation* — The difference between the recorded values of a quantity when an influence quantity assumes successively two specified values.

2.6.4 *Errors and Variations in the Measured Quantity*

2.6.4.1 *Error (or variation) expressed as a percentage of the fiducial value* — One hundred times the quotient of the absolute error (or variation) and the fiducial value as defined in **2.3.3.**

2.6.4.2 *Error (or variation) expressed as a percentage of the true value* — One hundred times the relative error (or relative variation).

2.6.4.3 *Error (or variation) expressed as a percentage of the chart scale length* — One hundred times the quotient of the absolute error (or variation) and the chart scale length, the values being expressed in the same units of length.

2.6.4.4 *Intrinsic error* — The error in the measured quantity and in time keeping determined when the instrument is under reference conditions, the friction effect being excluded while determining the error in the measured quantity.

2.6.5 *Friction Effect* — In the case of continuous line recording instrument, the effect which friction of the marking device on the chart may have on the record (*see* Appendix C).

The maximum value of this friction effect, measured according to **10.5** gives the measure of the greatest effect which may be observed, at any point on the chart, at any time, in the most unfavourable conditions. It may include in some cases effects due to play or certain hysteresis effects.

This value is expressed as a percentage of the chart scale length.

2.6.6 *Total Error of a Continuous Line Recorder in Specified Conditions* — The difference between the value read on the record and the true value.

The total error arises from a combination of the error (due to the measuring element) and of a part of the maximum value of the friction effect which depends on the following factors:

a) Deflection,
b) Chart speed,
c) Speed of variation of the measured quantity, and
d) The instant of reading.

When conditions are specified for each of these factors, Appendix B gives a method for determining this total error.

2.6.7 *Errors and Variations in Time-Keeping*

2.6.7.1 *Error (or variation) expressed as a percentage of the true time* — One hundred times the quotient of the absolute error (or variation) in time-keeping and the true time.

2.7 Accuracy — The accuracy of a recording instrument or of an accessory is characterized by:

a) the limits of intrinsic errors and the limits of variations in the measured quantity, and if relevant, the maximum value of the friction effect, and
b) the limits of intrinsic error and the limits of variations in time keeping.

2.7.1 *Accuracy Class Related to the Measured Quantity* — A classification, of measuring instruments (or their accessories), the accuracy of which may be designated by the same number, this being the upper limit of intrinsic error (that is, when the instrument is used under reference conditions).

The designating number is termed the *Class index of the instrument related to the measured quantity.*

NOTE 1 — Since in this standard the limits of variations and of the intrinsic error are both a function of the class index, therefore the definition of **2.7.1** may be applied to the variation as well as to the intrinsic error.

NOTE 2 — Recording instruments are thus classified in accuracy classes according to the limits of their intrinsic error, as defined in **2.6.4.4** (that is, disregarding the friction effect).

The friction effect, as defined in **2.6.5**, the nature of which differs from that of the intrinsic error, is dealt with in **10.5**.

The foregoing notion permits the classification of recording instruments and also comparison between them, but does not allow the user to ascertain easily the total error (including friction, if any) within which he may measure, because this depends upon a number of factors (for example, chart speed, deflection, speed of variation of the measured quantity and instant at which reading is taken).

To provide a means by which the manufacturer may indicate the limit of total error in specified condition, a recommended method is given in Appendix B.

2.7.2 *Accuracy Class Related to Time-Keeping* — A classification of recording instruments the time-keeping accuracy of which may be designated by the same number, this being the upper limit of the intrinsic error of time keeping (that is, when the instrument is used under reference conditions).

The designating number is termed the *Time-keeping class index.*

For one recording instrument with a number of rated chart speeds, the accuracy class related to time-keeping may vary with the chart speed.

3. CLASSIFICATION

3.0 General — Recording instruments and their accessories shall be classified as in **3.1** and **3.2**.

3.1 Recording Instruments — The instruments shall have one of the classes given in **3.1.1** and **3.1.2**.

3.1.1 *Accuracy Class Related to the Measured Quantity* — 0·2, 0·5, 1·0, 1·5, 2·5 and 5·0.

3.1.2 *Accuracy Class Related to the Time-Keeping* — 0·02, 0·05, 0·1, 0·2, 0·5, 1·0, 2·5, and 5·0.

3.2 Interchangeable Accessories (Shunts, Series Resistors, Inductors and Capacitors) (Also Accessories with Limited Interchangeability) — The interchangeable accessories of recording instruments shall have one of the following classes:

0·05, 0·1, 0·2, 0·5 and 1·0.

4. CONSTRUCTIONAL REQUIREMENTS

4.1 The constructional requirements shall conform to **4** (excepting **4.1**) of IS : 1248-1968*.

5. DIMENSIONS

5.1 The dimensions of flush-mounted square and rectangular recording instruments shall be as given in Table 1.

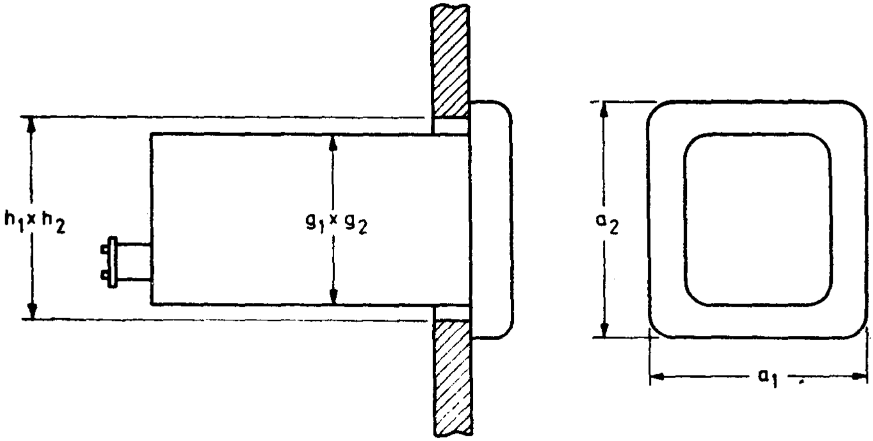
---

*Specification for direct acting electrical indicating instruments (*first revision*).

TABLE 1 FLUSH-MOUNTED SQUARE AND RECTANGULAR RECORDING ELECTRICAL INSTRUMENTS

(*Clause* 5.1)

All dimensions in millimetres.



Type	Nominal Size		g_1 Max	g_2 Max	h_1	h_2
	a_1	a_2				
Square	144	144	136	136	137+2	137+2
	192	192	184	184	185+2	185+2
	288	288	280	280	281+2	281+2
Rectangular	96	144	88	136	89+2	137+2
	96	192	88	184	89+2	185+2
	144	192	136	184	137+2	185+2
	192	240	184	232	185+2	233+2
	192	288	184	280	185+2	281+2
	288	192	280	184	281+2	185+2
	288	240	280	232	281+2	233+2
	324	240	316	232	317+2	233+2
	324	288	316	280	317+2	281+2

NOTE—The instruments covered by this table shall be suitably clamped at the rear.

6. MEASUREMENT RANGES

6.1 Instruments

6.1.1 The upper limit of the effective range of instruments shall *preferably* be chosen from following values or their decimal multiples or fractions:

1, 1·5, 3, 5 and 7·5.

6.1.2 The maximum value of the lower limit of the effective range of instruments shall conform to **5.1.2** of IS : 1248-1968*.

6.2 Shunts — The rated voltage drop of shunts shall preferably be one of the following values:

60, 75 and 150 mV.

6.2.1 The dimensions and applications of these shunts are given in Appendix C of IS : 1248-1968*.

6.3 Chart Speed

6.3.1 *Strip Chart and Drum Recording Instruments* — The rated chart speeds shall *preferably* be chosen from one of the following series:

a) 15, 30, 60, 120, 240 mm/h or mm/min.
b) 10, 20, 40, 60, 120, 240 mm/h or mm/min.

6.3.2 *Disc Recording Instruments* — The rated chart speeds shall *preferably* be chosen from the following series:

a) 1 revolution in 1, 2, 6, 8, 12 or 24 hours; or
b) 1 revolution in 7 days.

7. INTRINSIC ERRORS

7.1 Recording Instruments and Non-Interchangeable Accessories

7.1.1 *Error in the Measured Quantity* — When the instrument is under reference conditions as given in **7.1.2** and is used within the limits of the effective range, the intrinsic error shall not exceed the limits given in Table 2 as a function of class index of the instrument for the measured quantity.

Values stated in a table of corrections supplied with the instrument shall not be taken into account in determining the intrinsic errors.

NOTE — Intrinsic error is determined excluding friction of the marking device on the chart (for total error, *see* **2.6.6** and Appendix B).

TABLE 2 LIMITS OF INTRINSIC ERROR IN THE MEASURED QUANTITY

(*Clauses* 7.1.1 *and* 10.5.2)

Measured quantity class index	0·2	0·5	1·0	1·5	2·5	5·0
Limits of error (percent)	±0·2	±0·5	±1·0	±1·5	±2·5	±5·0

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*Specification for direct acting electrical indicating instruments (*first revision*).

7.1.1.1 The intrinsic errors shall be expressed as a percentage of fiducial value (*see* **2.3.3**).

7.1.2 *Conditions for the Determination of Intrinsic Errors in the Measured Quantity*

7.1.2.1 Before the determination of the intrinsic errors, the instrument shall be at the same temperature as the ambient temperature which later shall be the reference temperature (*see* Table 4) and its internal relative humidity shall be that of the ambient.

The instrument shall be set in operation according to the instructions of the manufacturer.

7.1.2.2 Before the preconditioning specified in Table 3, the marking device of any instrument where means are provided shall be set on the appropriate line of the reference chart, the latter being moved on a distance of 5 mm. In the case of dotted-line instruments, the instrument is set after three successive points have been printed on the appropriate chart line.

For wattmetres and varmeters, the marking device shall however be set on the appropriate line on the chart after energizing the voltage circuit(s).

7.1.2.3 All the measuring circuits of the instrument shall be left in circuit under the conditions and for the time specified in Table 3.

In the case of multiple measuring element instruments, all their measuring elements shall be energized under the conditions specified in Table 3.

TABLE 3 PRECONDITIONING OF INSTRUMENTS

(*Clauses* 7.1.2.2 *and* 7.1.2.3)

TEST CONDITIONS	ACCURACY CLASS RELATED TO THE MEASURED QUANTITY	
	0·2, 0·5	1·0, 1·5, 2·5, 5·0
Voltage (as percentage of rated voltage)	100	100
Current (as percentage of rated current)	100	80
Time between energizing and determination of errors	Any time (for convenience limited to 2 h)	½ h

7.1.2.4 The reference conditions relating to each of the influence quantities are given in Table 4.

The reference conditions relating to voltage, current and power factor are given in Table 5.

TABLE 4 REFERENCE CONDITIONS OF THE INFLUENCE QUANTITIES FOR DETERMINING THE INTRINSIC ERROR IN THE MEASURED QUANTITY*

[*Clauses* 7.1.2.1, 7.1.2.4, 7.2(a), 9.4(a) *and* 10.7]

Influence Quantity	Reference Conditions		Tolerance for the Reference Values Permitted for Testing Purposes (Accuracy Class Related to the Measured Quantity)	
	When Marked	In the Absence of Marking	0·2 and 0·5	1·0, 1·5, 2·5 and 5·0
Ambient temperature	Reference temperature or any temperature within the reference range	27°C	±1°C	±2°C
Position	Reference position	Any position	±1°	±1°
External magnetic induction	Reference external magnetic induction	Total absence of external induction	Value of induction of terrestrial magnetic field	
Ferromagnetic panel	Reference panel†	Non-magnetic panel	—	—
Conductive panel	Reference panel	Any panel	—	—
Frequency	Reference frequency or any frequency within the reference range	50 Hz	±2% or ±1/10 of nominal range of use (whichever be the less) For single-phase, varmeters and phasemeters : ±0·1%	±2% For single-phase, varmeters and phasemeters : ±0·2%
Wave-form of ac supply (related to the measuring circuit)	Reference wave-form	Sinusoidal	Distortion factor ⩽ 5% (for rectifier instruments ⩽ 1%)	

*Although the chart speed has an influence on the friction effect, the latter is eliminated in the determination of the intrinsic error, therefore the chart speed is not considered to be an influence quantity.

†*See* Table 11.

(*Continued*)

TABLE 4 REFERENCE CONDITIONS OF THE INFLUENCE QUANTITIES FOR DETERMINING THE INTRINSIC ERROR IN THE MEASURED QUANTITY* — *Contd*

INFLUENCE QUANTITY	REFERENCE CONDITIONS		TOLERANCE FOR THE REFERENCE VALUES PERMITTED FOR TESTING PURPOSES (ACCURACY CLASS RELATED TO THE MEASURED QUANTITY)	
	When Marked	In the Absence of Marking	0·2 and 0·5	1·0, 1·5, 2·5, and 5·0
Ripple content of dc supply (related to the measuring circuit)†	Reference ripple content	Zero	1%	3%
Chart	Reference chart	(*see* 2.5.4)	—	—
Quantity of ink	Any quantity within the reference range	40 to 60% of the pen capacity	—	—
Quality of ink	As specified by the manufacturer	—	—	—
Supply voltage	Rated voltage		±2%	±2%

*Although the chart speed has an influence on the friction effect, the latter is eliminated in the determination of the intrinsic error, therefore the chart speed is not considered to be an influence quantity.

†The ripple content of a dc (related to the measuring circuit) is defined as:

$$\frac{\text{Peak value} - \text{dc component}}{\text{dc component}} \times 100$$

7.1.2.5 Immediately before the test, the actual chart scale length is determined and marked on the chart.

The recorded value of the measured quantity is read:

a) either from a numbered rule, if such is supplied with the instrument; the zero mark of the rule — or the mark assigned by the manufacturer — shall coincide with the appropriate chart line. When using the rule, the actual length of the chart scale shall be checked and if this differs from that before the test, an appropriate correction shall be made; or

b) from the chart line. In this case, a correction is made by multiplying the measured value by the ratio of the actual to the rated chart scale length.

TABLE 5 REFERENCE CONDITIONS RELATIVE TO VOLTAGE, CURRENT AND POWER FACTOR

[*Clauses* 7.1.2.4, 9.4(a) *and* 10.7]

INSTRUMENTS	REFERENCE CONDITIONS		
	Voltage	Current	Power Factor
Wattmeters	Rated voltage ±2%	—	cos $\phi=1$ (tolerance 0·01) or rated cos $\phi \pm 0·01$
Varmeters	Rated voltage ±2%	—	sin $\phi=1$ (tolerance 0·01) or rated sin $\phi \pm 0·01$
Phasemeters	Rated voltage ±2%	Any current within the reference range. If not otherwise marked, the reference range is 40 to 100% rated current	—
Frequency meters and ohmmeters	Rated voltage ±2% or any voltage within the reference range	—	—
Polyphase instruments	Symmetrical voltages*	Symmetrical currents*	
Other elements of multiple measuring instrument†	a) Voltage measuring elements: 80% rated voltage. Other elements: rated voltage	Current measuring elements: 80% rated current. Other elements: 80% rated current	cos $\phi=1$ or rated cos ϕ
	b) Same conditions as for the measuring element under test		
	c) Conditioning according to Table 3, non-energized during the test.		

*Each of the voltages (between any two lines, or between line and neutral) of a polyphase symmetrical system shall not differ by more than 1 percent from the average of the voltages (line-to-line or line-to-neutral) of the system. Each of the currents in the lines shall not differ by more than 1 percent from the average of the currents. The angles between each of the currents and the corresponding line-to-neutral voltages shall not differ by more than 2 degrees.

†Reference conditions (a), (b) or (c) apply in the following cases:

a) instruments supplied with a connection diagram laying down the phase relationship of the elements,

b) instruments with internal connections and a common set of terminals, and

c) all other instruments.

7.1.2.6 The intrinsic errors are determined for increasing and decreasing values of the measured quantity according to the following methods:

a) *Continuous line recorder* — The chart being driven, the measured quantity is applied to the instrument under test and to a standard instrument, and progressively changed in such a way as to avoid overshoot until the required value is reached on the standard instrument.

For each value, the trace is recorded so that the friction effect is negligible. This may be achieved at any convenient chart speed and by any convenient means (including moving the chart by hand).

b) *Dotted line recorder* — The measured quantity is varied so that the exact value corresponding to the checkpoint is shown on the standard instrument.

The second dot is taken as the recorded value, the first being ignored. During this test, the chart should be running at such a speed that the two dots are easily distinguishable or, if necessary, the chart is moved forward by hand

All errors so obtained shall be within the limits specified in **7.1.1.**

7.1.3 *Errors of Instruments Including Means for Indication* — When a recording instrument is provided with an index and scale, the difference between the value read on the reference chart, and the indicated value on the scale shall not exceed the class index, expressed in terms of scale length, at any point, including zero, if any.

7.1.4 *Errors in Time-Keeping* — When the instrument is under reference conditions given in **7.1.5.1** the intrinsic error in time-keeping shall not exceed the limits given in Table 6 as a function of the time-keeping class index.

TABLE 6 LIMITS OF INTRINSIC ERROR IN TIME-KEEPING

Time-keeping class index	0·02	0·05	0·1	0·2	0·5	1·0	2·5	5·0
Limits of error (percent)	±0·02	±0·05	±0·1	±0·2	±0·5	±1·0	±2·5	±5·0

7.1.5 *Conditions for Determination of Errors in Time-Keeping*

7.1.5.1 The reference conditions are given in Table 7.

The chart-driving mechanism shall be set in operation according to the instructions of the manufacturer.

TABLE 7 REFERENCE CONDITIONS OF THE INFLUENCE QUANTITY FOR DETERMINING THE INTRINSIC ERROR IN TIME-KEEPING

[*Clauses* 7.1.5.1 *and* 9.4(a)]

Influence Quantity		Reference Conditions		Tolerance for the Reference Values Permitted for Testing Purposes
		When Marked	In the Absence of Marking	
Ambient temperature		Reference temperature or any temperature within the reference range	27°C	±2°C
Position		Reference position	Any position	
Running time (spring driven clockwork and running reserve for synchronous motors)		Rated running time		None
Synchronous motor or Impulse driven motor	Voltage	Rated voltage		±2%
	Frequency	Rated frequency		When the frequency is not equal to its rated value, the relevant correction shall be made*
	Wave-form	Reference wave-form given by the manufacturer		According to the instruction of the manufacturer

*This correction is permissible exclusively within the limits of frequency indicated by the manufacturer and for which the motor remains in synchronism with the supply frequency.

7.1.5.2 The recorded time is determined from the chart travel between the time marks of two abrupt changes of the measured quantity.

The time between these changes and the method of time measurement are chosen so that the error introduced by them is small in comparison with the intrinsic error in time-keeping of the instrument.

The chart-driving mechanism shall be driven for 15 minutes before the test, for a distinct movement of the marking device on the chart as a function of time to be observed.

Note 1 — It is assumed that the chart time lines are correctly printed and placed in relation to the chart perforations. In the case of unperforated charts, these lines are evenly printed in relation to the chart length or circumference.

NOTE 2 — For recording instruments with synchronous motors (without running reserve), the time shall be measured by means of a synchronous clock supplied by the same supply source as the instrument.

7.2 Interchangeable Accessories — The intrinsic errors are expressed in terms of a percentage of the rated value, the accessory being under the following reference conditions:

a) of temperature, frequency and wave-form as given in Table 4, except that, if the frequency is not indicated, the errors of shunts shall be determined on direct current; and

b) any voltage or current less than or equal to the rated values.

The error shall not exceed the limits indicated in Table 8 as a function of the class index.

TABLE 8 LIMITS OF INTRINSIC ERROR OF INTERCHANGEABLE ACCESSORIES

Class index of accessory	0·05	0·1	0·2	0·5	1·0
Limits of error (percent)	±0·05	±0·1	±0·2	±0·5	±1·0

The above conditions and requirements are also applicable to accessories having limited interchangeability.

8. LIMITS OF VARIATIONS IN RECORDING

8.1 Recording Instruments and Non-Interchangeable Accessories

8.1.1 *Variation for the Measured Quantity* — When the instrument is under the reference conditions given in **7.1.2** and a single influence quantity is varied in accordance with **8.1.2**, the absolute value of the resultant variation in recording when determined in accordance with **8.1.2.2** shall not exceed:

a) the class index for the influence quantities listed in Table 9,

b) the limits stated in **8.1.3** to **8.1.7** for the other influence quantities.

o.1.1.1 The variations are expressed in the manner indicated in **7.1.1.1** for the expression of intrinsic errors.

8.1.2 *Conditions for Determination of Variations for the Measured Quantity*

8.1.2.1 The variations shall be determined for each influence quantity. During each determination all other influence quantities shall be maintained at their reference conditions.

8.1.2.2 The determination of the variations associated with the influence quantities listed in Table 9 and **8.1.3** to **8.1.7** shall be made at two points on the scale:

a) between 40 and 60 percent of the upper limit of the effective range. When these values are not contained within the effective range (as may be the case with suppressed-zero instruments), the test point shall be taken near the lower limit of the effective range,

b) between 80 and 100 percent of the upper limit of the effective range.

Certain influence quantities, such as position, power factor and voltage (wattmeters and varmeters) may also require measurements at zero.

8.1.2.3 A variation is determined by means of two successive measurements, for the two values of the influence quantity given in **8.1.2.4**, the variation being the difference between these two measurements. Each of these two measurements is affected for increasing and decreasing values, by retaining the mean value of the recorded values. For each measurement, the trace is recorded as prescribed for determination of errors (*see* **7.1.2.6**) so that the effect of friction is negligible.

NOTE — *For wattmeters and varmeters,* the value of power shall be increased and decreased by varying only the value of the current.

8.1.2.4 The degree of variation is assessed as follows:

a) When a *reference value* is assigned to the instrument* the influence quantity may be varied between that value and any value within the limits of the nominal range of use as given or prescribed in Table 9.

b) When a *reference range* is assigned to the instrument* without giving a nominal range of use, there are no requirements outside the reference range, and therefore the determination of variation is not applicable.

c) When the limits of the *reference range* and the *nominal range* of use are assigned to the instrument*, the influence quantity may be varied between each of the limits of the reference range and any value of that part of the nominal range of use adjacent to the chosen limit of the reference range.

8.1.3 *Influence of External Magnetic Induction*

8.1.3.1 For instruments marked with the symbol **A-6.31** (*see* IS : 1248-1968†), such a value of current in the test equipment is chosen that, in the

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*The markings shall comply with **9.4**, where there are no such markings, the reference conditions are given in Table 4; the limits of the nominal range of use are given in Table 9.

†Specification for direct acting electrical indicating instruments (*first revision*).

absence of the instrument under test, a magnetic induction is produced having a value, in militesla, as shown in the symbol. Under these conditions, the variation in recording shall not exceed the class index.

TABLE 9 LIMITS OF THE NOMINAL RANGE OF USE OF THE INFLUENCE QUANTITIES RELATIVE TO THE MEASURED QUANTITY (APPLICABLE WHERE THERE IS NO INDICATION)

[*Clauses* 8.1.1(a), 8.1.2.2, 8.1.2.4(a), 8.2.2 *and* 9.4(b)]

INFLUENCE QUANTITY*	LIMITS OF NOMINAL RANGE OF USE	
Ambient temperature	Reference temperature ±10°C	
Position†	Reference position ±5°	
Frequency	Reference frequency ±10%	
Voltage	Reference voltage ±10%	
Current (for power-factor meters)	20 and 120% of rated current	
External magnetic induction‡	0 and 0·5 mT	
	Instruments of Classes 0·2, 0·5	Instruments of Classes 1·0, 1·5, 2·5, 5·0
Power factor ($\cos \phi$) for wattmeters	Rated $\cos \phi$ and $\cos \phi = 0$	Rated $\cos \phi$ and 1/2 rated $\cos \phi$ lagging
$\sin \phi$ for varmeters	Rated $\sin \phi$ and $\sin \phi = 0$	Rated $\sin \phi$ and 1/2 rated $\sin \phi$ lagging

*Although the chart speed has an influence on the friction effect, the latter is eliminated in the determination of the intrinsic error, therefore the chart speed is not considered to be an influence quantity, and has no nominal range of use.

†Instruments provided with levelling means are excluded from these requirements. Further, if a change in a certain direction is precluded by the manufacturer's instructions, the test need be carried out only in the other directions.

‡In the case of an induction, this is the rms value (*see* **8.1.3**).

8.1.3.2 When the instrument is not marked with the symbol **A-6.31** (*see* IS : 1248-1968*) such a value of current in the test equipment is chosen that, in the absence of the instrument under test, a magnetic induction is produced having a value of 0·5 mT. Under these conditions, the variation in recording shall not exceed the limits given in Table 10.

8.1.3.3 The induction produced shall always be in the most unfavourable direction relative to the instrument.

For instruments which are only usable on direct current, the induction shall be produced by a direct current.

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*Specification for direct acting electrical indicating instruments (*first revision*).

TABLE 10 LIMITS OF VARIATION FOR A MAGNETIC INDUCTION OF 0·5 mT

(*Clause* 8.1.3.2)

INSTRUMENTS	ACCURACY CLASS	
	0·2, 0·5	1·0, 1·5, 2·5 and 5
(1)	(2)	(3)
Moving coil Astatic Magnetically screened	±1·5%	±3%
Others	±3%	±6%

For ac instruments, intended for use at frequencies equal to or less than 1 000 Hz, the induction shall be produced by an alternating current having a frequency within the reference range of the instrument and under the most unfavourable condition of phase.

For ac instruments having reference range of frequency extending beyond 1 000 Hz, the induction shall be produced by a current having a frequency of 1 000 Hz.

8.1.3.4 *Recommended method of determining the variation due to the influence of magnetic induction of external origin* — The instrument is placed with the measuring element in the centre of a coil of 1 m mean diameter of square section and of radial thickness small compared with the diameter and passing such a current as will produce, at the centre of the coil the magnetic induction specified in **8.1.3.1** or **8.1.3.2***.

Instruments having any maximum external dimension exceeding 250 mm should be tested in a coil of mean diameter not less than four times the maximum dimensions of the instrument, the resulting excitation being maintained at the values specified in **8.1.3.1** or **8.1.3.2**.

8.1.4 *Influence of Mounting on Ferro-Magnetic Supports*

8.1.4.1 All instruments bearing the symbol 'Fex' (*see* Table 11) shall be used on a ferro-magnetic panel of the thickness specified. It is not required that they be tested for the effect of mounting on other panels.

8.1.4.2 All instruments bearing the symbols Fe, NFe or Fe.NFe (*see* Table 11) shall meet the requirements of **7.1**, when mounted on a panel of the nature specified and of any thickness.

8.1.4.3 Switchboard or panel instruments not marked in accordance with Table 11, when used on a ferro-magnetic panel having a thickness of 3 ± 0·5 mm, shall not show variations exceeding half the class index.

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*When the magnetic induction is taken equal to 0·5 mT, according to **8.1.3.2**, the magnetomotive force is 400 ampere turns.

8.1.4.4 Portable instruments not marked in accordance with Table 11 are not required to be tested for the effect of mounting on ferro-magnetic supports.

TABLE 11 EFFECT OF MOUNTING ON A FERRO-MAGNETIC PANEL (CONDITIONS OF TEST AND LIMITS OF VARIATIONS)

[*Clauses* 8.1.4.1, 8.1.4.2, 8.1.4.3, 8.1.4.4 *and* 9.1.2 (b)]

SYMBOL	REFERENCE CONDITIONS		TEST CONDITIONS		LIMITS OF VARIATION IN RECORDING (CLAUSE REF)
	Nature of Panel	Thickness mm	Nature of Panel	Thickness mm	
Fex	Ferrous	x±0·5	No test required		8.1.4.2
Fe	Ferrous	Any	Ferrous	Any	
NFe	Non-ferrous		Non-ferrous		
Fe.NFe	Any		Any		
No symbol	Non-ferrous		Ferrous	3±0·5	8.1.4.3

8.1.5 *Influence of Mounting on Supports of Conductive Material*

8.1.5.1 Unless marked with the symbol **A-6.34** (*see* IS : 1248-1968*) instruments shall meet the requirements of **7.1** when mounted on a support of conductive material.

8.1.6 *Influence of Unbalanced Currents on the Performance of Polyphase Wattmeters and Varmeters*†.

8.1.6.1 The variations due to unbalanced currents shall be determined in the following manner:

> The instruments shall be under the reference conditions stated in **7.1.2.** Notwithstanding the requirements of **8.1.2.2,** the currents shall be adjusted so that the recording is approximately in the middle of the effective range. The difference between recorded value and true value is noted.
>
> The instrument is then maintained at the reference conditions with the exception that one current is disconnected. The voltages are maintained balanced. The other currents are adjusted so as to give the initial recording. The new difference is then determined.
>
> The variation which arises as a result of unbalanced currents shall not exceed twice the class index.

8.1.7 *Influences Due to the Marking Device* — Continuous line recording instruments shall comply with the following requirements, according to the type of marking device.

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*Specification for direct acting electrical indicating instruments (*first revision*).

†This requirement is not applicable to single-phase instruments calibrated in terms of polyphase power.

8.1.7.1 *Influence of the quantity of ink* — The variation which arises as a result of a change of the quantity of ink in the pen or in the ink well shall not exceed half the class index when the quantity of ink is changed within one of the limits of the reference range and the corresponding limit of the nominal range of use [*see* **8.1.2.4** (c)].

When there is no indication, the limits of the nominal range of use for the quantity of ink are 10 and 100 percent of the maximum quantity.

8.1.7.2 *Influence of the stylus supply voltage* — When the supply voltage of the stylus is changed between its rated value and the limits of the nominal range of use, the variation which arises as a result of the change shall not exceed half the class index. When there is no marking, the limits of the nominal range of use are 90 and 110 percent of the rated voltage.

8.1.8 *Variations in Time-keeping* — When the instrument is under the reference conditions given in **7.1.2** and a single influence quantity is varied in accordance with **8.1.8.1**, the variation shall not exceed the time-keeping class index.

8.1.8.1 *Conditions for determination of variations in time-keeping* — The variations shall be determined for each influence quantity shown in Table 12. During each determination, this influence quantity may be varied between the reference value and any value within the limits of the nominal range of use, all other influence quantities being maintained at their reference conditions.

When there is no indication, the limits of the nominal range of use are those given in Table 12.

TABLE 12 LIMITS OF THE NOMINAL RANGE OF USE OF THE INFLUENCE QUANTITIES RELATIVE TO TIME-KEEPING (APPLICABLE WHERE THERE IS NO INDICATION)

[*Clauses* 8.1.8.1 *and* 9.4(b)]

INFLUENCE QUANTITY	NOMINAL RANGE OF USE	CHART-DRIVING MECHANISM
Ambient temperature	Reference temperature ± 10°C	Spring-driven clockwork
Voltage	Rated voltage ± 10%	Synchronous motor or impulse-driven motor
Position	Reference position ± 5°	All mechanisms

8.1.8.2 The total error in time-keeping for a *synchronous motor* mechanism with running reserve, during the duration of the rated running-time of the running reserve stated by the manufacturer, shall not exceed the limit specified [*see* **9.1.1**(f)].

8.1.8.3 When the manufacturer specifies a total running-time (exceeding the rated running-time) for a *spring-driven clockwork*, hand-wound or electrically wound, the error in time-keeping during the additional period shall not exceed twice the class index.

8.2 Interchangeable Accessories

8.2.1 The variations shall be expressed as a percentage of the rated value.

8.2.2 The variations produced by the influence of temperature, frequency or voltage shall not exceed the class index, the nominal range of use being as given in Table 9.

9. MARKING

9.1 Markings and Symbols for Recording Instruments — Recording instruments shall bear on any surface accessible to the user the markings listed below. The markings given in **8** of IS : 1248-1968* shall also apply in addition to those given in **9** of this standard.

NOTE — In case of inconsistencies between the markings given in IS : 1248-1968* and this standard, the provisions of latter shall apply.

The majority of these markings are made using the symbols given in Appendix A.

NOTE — Unless otherwise specified accuracy classes are related to the measured quantity.

9.1.1 *Markings and Symbols Made on All Instruments* (*see also* **8.1.1** *of* IS : 1248-1968*)

a) Serial number for instruments of Classes 0·2 and 0·5,

b) Chart-driving mechanism (symbols **A-7.1** to **A-7.7**),

c) Time-keeping accuracy class(es) (symbols **A-7.1** to **A-7.5**),

d) Chart speed(s) (linear or rotary) (symbols **A-7.1** to **A-7.6**),

e) Rated voltage and frequency of the supply of the chart-driving mechanism, if applicable (symbols **A-7.3** to **A-7.6**),

f) Rated running time, for spring-driven clockworks hand-wound or electrically wound (symbols **A-7.1** to **A-7.3**) or rated running time of running reserve (symbol **A-7.5**),

g) Total running time for spring-driven clockworks (symbols **A-7.2** and **A-7.3**), and

h) Where relevant, the limit of the maximum value of friction effect (symbol **A-8.1**), if not expressed by the same number as the accuracy class†.

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*Specification for direct acting electrical indicating instruments (*first revision*).

†This limit shall always be marked in the case of suppressed zero instruments.

9.1.2 *Markings and Symbols to be Marked on the Instruments when Necessary (or on a Document Supplied with the Instrument)* (*see also* **8.1.2** of IS : 1248-1968*)

a) Values of resistance, reactance or impedance at the rated frequency, for the current and voltage circuits of instruments of accuracy Classes 0·2 and 0·5;

b) Symbol showing the panel for which the instrument has been calibrated (Table 11);

c) Value of the source impedance when knowledge of it is necessary for damping and overload tests (*see* **10.6.3** and **10.8.2**);

d) Upper limit of the frequency response (*see* **2.1.4**, **2.4.3** and **10.6.6**);

e) The impulse characteristics in the case of impulse-driven motors;

f) The voltage and frequency operating limits of synchronous motors; and

g) The supply voltage of the marking device and its limits, if necessary.

9.2 Markings and Symbols for Shunts — Shunts shall bear the following markings.

9.2.1 *Non-Interchangeable Shunts* — *See* **8.2.1** of IS : 1248-1968*.

9.2.2 *Interchangeable Shunts* — *See* **8.2.2** of IS : 1248-1968*.

a) Serial number, for shunts of accuracy Classes 0.05 and 0.1 only.

9.3 Markings and Symbols for Resistors, Inductors and Capacitors Used as Accessories — Resistors, inductors and capacitors shall bear the following markings.

9.3.1 *Non-Interchangeable Resistors, Inductors and Capacitors* — *See* **8.3.1** of IS : 1248-1968*.

9.3.2 *Interchangeable Resistors, Inductors and Capacitors* — *See also* **8.3.2** of IS : 1248-1968*.

a) Serial number, for accessories of accuracy Classes 0.05 and 0.1 only, and

b) When the interchangeability is limited, resistance or impedance of the type of instrument to be used with the accessory.

9.4 Markings Relative to the Reference Conditions and Nominal Range of Use — *See also* **8.4.1** of IS : 1248-1968*.

a) The reference values or reference ranges corresponding to each

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*Specification for direct acting electrical indicating instruments (*first revision*).

influence quantity shall be marked if different from those given in Tables 4, 5 and 7.

b) The nominal range of use shall be marked if different from those given in Tables 9 and 12, except where only a reference range is marked [*see* **8.1.2.4**(b)].

9.5 The product may also be marked with Standard mark.

9.6 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manfucaturers or producers may be obtained from the Bureau of Indian Standards.

10. TESTS

10.1 General

10.1.1 *Type Tests* — The following shall constitute type tests:

a) Insulation resistance (*see* **9.2** of IS : 1248-1968*),
b) High voltage (**10.3**),
c) Accuracy (**10.4**),
d) Maximum value of friction effect for continuous line recording instruments (**10.5**),
e) Damping (**10.6**),
f) Continuous load (**10.7**),
g) Overloads (**10.8**),
h) Mutual influences (**10.9**),
j) Vibration test (**10.10**),
k) Dry heat test (*see* **9.11** of IS : 1248-1968*),
m) Dry cold test (*see* **9.12** of IS : 1248-1968*), and
n) Damp heat (cycling) test (*see* **9.13** of IS : 1248-1968*).

10.1.2 *Routine Tests* — The following shall be carried out as routine tests:

a) Insulation resistance (*see* **9.2** of IS : 1248-1968*),
b) High voltage (**10.3**), and
c) Accuracy (**10.4**).

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*Specification for direct acting electrical indicating instruments (*first revision*).

10.2 Atmospheric Conditions for Testing — Unless otherwise specified, the tests, shall be carried out under the atmospheric conditions specified in **3.2** of IS : 196-1966*.

10.3 High Voltage — Instruments and their accessories shall withstand the tests given in **10.3.1** to **10.3.4**.

10.3.1 *High Voltage Test Between Measuring Circuits and Case* — The test shall be carried out in accordance with **9.3.1** of IS : 1248-1968†.

10.3.1.1 The terminal of the supply circuits of the chart driving mechanism, if any, shall be connected together and to the case or the conducting surface.

10.3.2 *High Voltage Test Between Voltage and Current Circuits* — A further voltage test shall be made between the voltage and the current circuits of wattmeters, varmeters and power factor meters, unless the circuits are commoned within the case when they are considered as a single circuit.

The test voltage shall be twice the nominal circuit voltage with a minimum of 500 V.

As an exception, the test voltage is limited to 50 V in the case of wattmeters and varmeters with voltage circuit compensation [symbol **A-6.34** (*see* IS : 1248-1968†) to be shown in this case].

10.3.3 *High Voltage Test Between Electrical Circuits of Electrically Measuring Instruments* — Unless otherwise specified, the test voltage between the independent electrical circuits of electrically measuring instruments shall be 500 V.

10.3.4 *High Voltage Test of the Auxiliary Supply Circuit(s)* — When there is an auxiliary source of supply (for the chart-driving mechanism, electrical marking device, etc), the following high voltage test shall be carried out:

The test voltage shall be applied between the terminals of the auxiliary source of supply connected together, and the casing or the conducting surface. The terminals of the measuring circuit are connected to the casing or to the conducting surface.

The value of the test voltage is determined according to the rated voltage of the supply circuits as follows:

Rated Supply Voltage V	*Test Voltage* kV (rms)
Up to and including 24	No high voltage test
Above 24 up to and including 40	0·5
Above 40 up to and including 650	2

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*Atmospheric conditions for testing (*revised*).

†Specification for direct acting electrical indicating instruments (*first revision*).

10.4 Accuracy

10.4.1 The instruments shall be checked for conformity to the provisions of **7** and **8**.

10.4.2 Instruments should be tested by direct comparison with instruments of known accuracy having intrinsic error 1/2 or less that of the instrument under test. In case instruments of higher class of accuracy (such as 0·05 class) are to be tested, methods other than direct comparison should be used. Such method and equipment should be capable of at least twice the accuracy that of the instrument under test.

10.4.2.1 The most accurate method of testing one instrument with a standard instrument of higher precision is to adjust the current until the marking device or the marking device and pointer of the instrument under test are on definite scale marks, and to note the deviation of the reading from the corrected reading of the standard instrument. This method should be used when testing an instrument with precision and accuracy, and also for testing instruments where a table of correction is required.

10.4.2.2 A more convenient but less accurate method of testing instruments is to adjust the current until the marking device or the marking device and pointer of the standard instrument are on the scale mark and to note the deviation of the reading of the instrument under test from that of the standard instrument. If the deviation from the standard value is clearly within the permitted limits, the instrument should be considered to comply with the requirements of the specification. If, however, any doubt exists by reason of this method of testing, the check readings should be made by the more accurate method described in **10.4.2.1**.

10.5 Maximum Value of Friction Effect for Continuous Line Recording Instruments

10.5.1 The maximum value of friction effect (ε_f) is determined under the following conditions:

a) Tests shall be taken at each of three values on the chart scale, chosen between:
   1) 5 and 15 percent,
   2) 45 and 55 percent, and
   3) 85 and 95 percent of the chart scale length.

b) The chart being stationary, the measured quantity is applied to the instrument under test and to a standard instrument, and progressively increased in such a way as to avoid overshoot until the required value is reached on the standard instrument, then reduced by 5 percent (approximately) of the chart scale length. The chart is then advanced by hand by 2 mm (approximately) and the measured quantity is taken to a value exceeding the chosen value by 5 percent (approximately). The chart is again advanced by 2 mm (approximately) and the measured quantity reduced to the chosen value, then again increased and so on (*see* Fig. 1).

This process is carried out three times for the first value and the other two values are then treated in exactly the same manner.

c) The trace so obtained gives for each of the three values three groups of two reversal points, the distance between which is noted. For each value the greatest distance is disregarded.

d) The maximum value of friction effect is taken to be equal to half the greatest of the six remaining values. It is expressed as a percentage of the chart scale length.

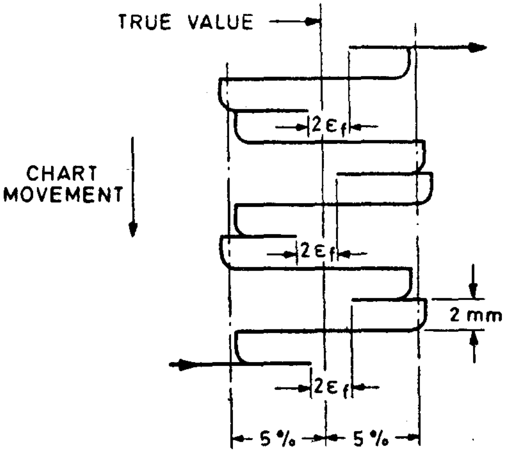

FIG. 1 DETERMINATION OF MAXIMUM VALUE OF FRICTION EFFECT

10.5.2 The maximum value of friction effect determined according to **10.5.1** shall not exceed the limit specified by the manufacturer and marked on the instrument (symbol **A-8.1**). This limit is preferably chosen out of the values of Table 2.

However, if this limit is the same number as the class index related to the measured quantity, it need not be marked on the instrument.

NOTE — In the case of suppressed zero recording instruments, this limit shall always be marked.

10.6 Damping — The damping of a recording instrument shall comply with the following requirements.

10.6.1 *Overshoot* — The instrument is instantaneously connected to a circuit where the value to be measured is such that it would produce a steady reading of 2/3 of the upper limit of the effective range. The maximum deflection shall not exceed the final steady deflection by a quantity more than 7 percent of the chart scale length.

This requirement does not apply to dotted line recorders.

NOTE — When the zero of the instrument is displaced within the chart scale, the chart scale length for determining the overshoot shall be taken as being the longer of the chart scale lengths on either side of the zero.

When the zero of the instrument is suppressed (is not on the scale), the chart scale length for determining the overshoot shall be taken as being the length of the curved or straight line between the extreme scale marks.

10.6.2 *Damping Time* — When the instrument is under the same conditions as specified in **10.6.1**, the instrument shall comply with the following requirements:

a) *Continuous line recording instruments* — The time required for the marking device to settle within a percentage equal to the class index, at its final steady position, shall not exceed 4 seconds.

b) *Dotted line recording instruments* — The damping time should be appreciably less than the time interval between the recording of two successive dots.

10.6.3 When the characteristics of the circuit into which the recording instrument is connected may affect the damping, the source impedance should be that stated in accordance with **9.1.2**(c).

When there is no such marking, the requirements of **10.6.1** and **10.6.2** are valid for any value of source impedance.

10.6.4 The requirements of **10.6.1** and **10.6.2** do not apply to the following types of recording instrument:

a) bimetallic instruments,

b) instruments specially designed with a long damping time and bearing symbol **A-6.34** (*see* IS : 1248-1968*), and

c) electrically measuring instruments.

10.6.5 *Limits of the Thickening of the Trace* — The thickening of the trace resulting from parasitic vibration of the marking device due to the application of the measured quantity shall not exceed half the class index, expressed in terms of the chart scale length.

This test shall be made at any frequency of the nominal range of use.

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*Specification for direct acting electrical indicating instruments (*first revision*).

10.6.5.1 *Thickness of trace* — The maximum thickness of the line recorded on the chart shall be in accordance with the following formula:

$$\delta = \frac{0{\cdot}01.c.L}{3} + 0{\cdot}2$$

where

δ = maximum thickness of the trace in millimetres,
c = class index related to the measured quantity, and
L = chart scale length in millimetres.

10.6.6 *Recording at the Upper Limit of the Frequency Response (Applicable to Continuous Line Recording Instruments Only)* — The test shall be made with the zero of the sinusoidally varying quantity approximately at the mid-point of the effective range.

The quantity shall have a peak-to-peak amplitude of approximately 2/3 of the effective range. The chart shall be moving at the highest rated chart speed and the marking device shall record at least one complete cycle as a continuous line.

During this test, the recorded values (peak-to-peak) shall not differ from the true value by more than 10 percent.

10.7 Continuous Load — All instruments, together with their accessories, shall comply with the requirements appropriate to their accuracy class related to the measured quantity when they are continually loaded at the upper limit of their effective range under the reference conditions stated in Tables 4 and 5.

10.8 Overloads

10.8.1 *Continuous Overload* — The continuous overload test shall be in accordance with **9.7.1** of IS : 1248-1968*.

10.8.2 *Overloads of Short Duration* — The overloads of short duration which instruments shall withstand without damage are given in Table 13, the test circuit being practically non-inductive. When the damping is affected by the external circuit [*see* **9.1.2**(c)], the test circuit should conform with the prescribed values.

An instrument with mechanical zero is considered to be undamaged when after the test and after the instrument has been cooled to its reference temperature:

a) the zero variation expressed as a percentage of the chart scale length is less than:
    1) 0·5 percent for instruments of Classes 0·2 and 0·5 related to the measured quantity.

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*Specification for direct acting electrical indicating instruments (*first revision*).

  2) Class index for instruments of the other classes related to the measured quantity.

- b) the instrument after re-adjustment of the zero, and if necessary resetting and refilling the pen meets the requirements of **7.1**.

An instrument without mechanical zero is considered to be undamaged if it satisfies the requirements of **7.1** after the instrument has been cooled to the reference temperature and after any necessary resetting and refilling of the pen.

Quotientmeters of Classes 1·0, 1·5, 2·5 and 5·0 related to the measured quantity shall be tested at rated voltage to determine the effect of interruption of one of the measuring circuits.

Before the interruption, the marking device of the instruments shall be deflected electrically to the centre of the chart scale length.

The interruptions, each of 2 seconds duration, shall be repeated ten times, and the time between tests during which the instrument is reconnected in the circuit shall be 10 seconds. After this test, the quotientmeter shall satisfy requirements appropriate to its accuracy class related to the measured quantity.

The following instruments are excluded from the requirements of this clause:

a) bimetallic instruments,
b) rectifier instruments,
c) thermocouple instruments, and
d) electrically measuring instruments.

10.9 Mutual Influences

10.9.1 *Mutual Influence Between the Different Circuits of Polyphase Wattmeters and Varmeters* — The variations arising from mutual effects between the defferent circuits of polyphase wattmeters and varmeters shall not exceed the measured quantity class index.

The following method is recommended for the determination of the effect of mutual influences:

All the circuits (voltage as well as current) shall be energized at their rated value and one voltage circuit is then disconnected. The changes in recording shall be noted as the current in the circuit associated with the disconnected voltage circuit is varied in phase through 360°. The difference between the extreme values of recordings so obtained shall not exceed twice the measured quantity class index. The test is repeated with each voltage circuit disconnected in turn, and a similar series of tests

TABLE 13 OVERLOAD TEST OF SHORT DURATION

(*Clause* 10.8.2)

Instruments	Current (as a Multiple of Rated Current) (*see* Note 1)	Voltage (as a Multiple of Rated Voltage) (*see* Note 1)	Number of Overloads	Duration of Each Overload (Seconds)	Interval Between Overloads (Seconds)
	Accuracy Classes 0·2, 0·5*				
Ammeters	2	—	5	(*see* Note 2)	15
Voltmeters and frequency meters	—	2	5	(*see* Note 2)	15
Wattmeters, varmeters and phasemeters	1	2	1	5	—
	2	1	5	(*see* Note 2)	15
	Accuracy Classes 1·0, 1·5, 2·5, 5·0*				
Ammeters	5	—	9	0·5	60
	5	—	1	5	—
Voltmeters and frequency meters	—	2	9	0·5	60
	—	2	1	5	—
Wattmeters, varmeters	5	1	9	0·5	60
	5	1	1	5	—
	1	2	1	5	—

Note 1 — The test shall be made under reference conditions (*see* **7.1.2**).

Note 2 — The duration of the overload should be just long enough for the marking device to deflect so as to swing over the upper chart scale mark.

*Accuracy classes are related to the measured quantity.

should be made with all the voltage circuits energized and the current circuits disconnected in turn.

10.9.2 *Mutual Influence Between the Different Measuring Elements of a Multiple Measuring Element Instrument* — The variation arising from a mutual effect between the different measuring elements is determined by energizing one measuring element so that a deflection of 80 percent of the upper limit of the effective range is obtained; the value measured by each of the other measuring elements is then varied from the maximum to the minimum within the limits of their effective ranges in the most unfavourable phase conditions. The maximum variation in the recording of the first measuring elements is noted and the test repeated in turn on every measuring element.

Any variation shall not exceed half the class index.

This requirement does not apply to instruments the measuring elements of which are internally connected and have a common set of terminals.

10.10 Vibration Test — (Not applicable to all instruments of 0·2 and 0·5 accuracy class* and portable instruments of 1·0 accuracy class*).

10.10.1 The test shall be carried out in accordance with **9.9** of IS : 1248-1968†.

After the application of the vibrations the specimen under test shall satisfy the requirements given in **7**.

APPENDIX A

(*Clauses* 9.1, 9.1.1, 10.3.2 *and* 10.5.2)

SYMBOLS FOR MEASURING APPARATUS

A-1. SYMBOLS OF THE PRINCIPAL UNITS AND THEIR PRINCIPAL MULTIPLES AND SUB-MULTIPLES

A-1.1 The symbols shall be in accordance with those given in **A-1** of IS : 1248-1968†.

A-2. SYMBOLS FOR TYPE OF SUPPLY FOR WHICH APPARATUS IS INTENDED

A-2.1 The symbols shall be in accordance with those given in **A-2** of IS : 1248-1968†.

A-3. SYMBOLS OF DIELECTRIC TEST VOLTAGE

A-3.1 The symbols shall be in accordance with those given in **A-3** of IS : 1248-1968†.

A-4. SYMBOLS FOR REFERENCE POSITION OF USE

A-4.1 The symbols shall be in accordance with those given in **A-4** of IS : 1248-1968†.

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*Accuracy class related to measured quantity.

†Specification for direct acting electrical indicating instruments (*first revision*).

A-5. SYMBOLS FOR ACCURACY CLASS

A-5.1 The symbols shall be in accordance with those given in **A-5** of IS : 1248-1968*.

A-6. SYMBOLS INDICATING THE METHOD OF OPERATION OF THE INSTRUMENT AND ACCESSORIES

A-6.1 The symbols shall be in accordance with those given in **A-6** of IS : 1248-1968*.

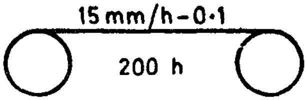
A-7. SYMBOLS FOR CHART-DRIVING MECHANISM

A-7.1 Spring-Driven, Hand-Wound Clockwork

Rated chart speed : 15 mm/h

Rated running time : 8 days

Time-keeping accuracy class : 0·1



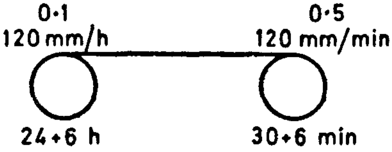
A-7.2 Spring-Driven, Hand-Wound Clockwork with Two Rated Chart Speeds

Rated chart speeds: 120 mm/h, and 120 mm/min

Rated running time: 24 h and 30 min respectively

Total running time: 30 h and 36 min respectively

Time-keeping accuracy class:
0·1 at 120 mm/h
0·5 at 120 mm/min



A-7.3 Spring-Driven, Electrically Wound Clockwork

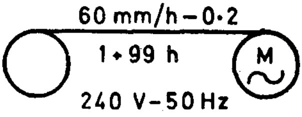
Rated chart speed : 60 mm/h

Supply : 240 V-50 Hz

Rated running time : 1 h

Total running time : 100 h

Time-keeping accuracy class : 0·2

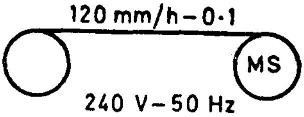


A-7.4 Synchronous Motor

Rated chart speed : 120 mm/h

Supply : 240 V-50 Hz

Time-keeping accuracy class 0·1



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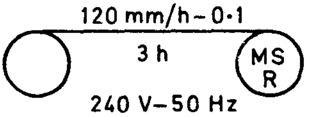
*Specification for direct acting electrical indicating instruments (*first revision*).

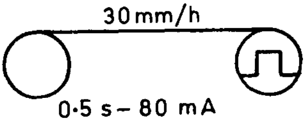
A-7.5 Synchronous Motor with Running Reserve

Rated chart speed : 120 mm/h
Supply : 240 V-50 Hz
Running reserve : 3 h
Time-keeping accuracy class : 0·1

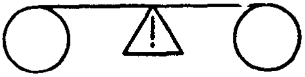


A-7.6 Impulse-Driven Motor

Rated chart speed : 30 mm/h
Current supply : 80 mA
Impulsing rate : 0·5 s

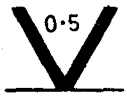


A-7.7 Any Other Chart Driving Mechanism



A-8. SYMBOLS FOR FRICTION EFFECT

A-8.1 Maximum value of the friction effect (for example, 0·5) expressed as a percentage of chart scale length



APPENDIX B

(*Clauses* 2.6.6, 2.7.1, 7.1.1 *and* C-3.8)

RECOMMENDED METHOD FOR THE DETERMINATION OF TOTAL ERROR IN SPECIFIED CONDITIONS

B-1. GENERAL

B-1.1 The method recommended enables the total error to be determined for a given point of the effective range in specified conditions, the chart-driving mechanism running at the chart speed that has been selected for this determination.

B-2. TOTAL ERROR

B-2.1 The total error in the recording of a given value of the measured quantity by a continuous line recording instrument comprises:

a) the intrinsic error which may be determined for this value in accordance with the requirements of **7.1.2.6**; and

b) the part of the error due to friction effect which may be observed in normal operation, excluding possible transient dynamic effects of the measuring element.

B-3. METHOD

B-3.1 The instrument shall be set in operation in accordance with the requirement of **7.1.2.1** and with the manufacturer's instructions.

B-3.2 The chart being driven, the measured quantity is applied to the instrument under test and to a standard instrument and progressively increased in two stages up to a selected value on the standard instrument:

a) rapidly but without going beyond, up to a value which differs from the selected value by a quantity not less than 4 times the class index of the instrument under test;

b) gradually from this lower value up to the selected value so that the speed of variation of the measured quantity is between 1 and 2 percent of the upper limit of the effective range per second.

B-3.3 The selected value being reached, the measured quantity is maintained constant for a period fixed at 5 times the damping time of the instrument, then varied quickly in the reverse direction so as to obtain a cusp on the trace.

B-3.4 The chart is then moved by hand or by the driving mechanism so as to obtain a length of trace of 1 or 2 mm; the measured quantity is then varied up to the upper limit of the effective range.

B-3.5 The same operations are carried out in the reverse direction from the upper limit down to the selected value, so as to obtain a new cusp.

B-3.6 The greater difference between the cusp and the value measured on the chart either for increasing or decreasing values, corresponds to the total error which equals ε_x for the point X (*see* Fig. 2).

B-3.7 In the case of chart speeds up to and including 20 mm/h, several checks should be carried out, in order to obtain an average value and eliminate the random effect of friction.

NOTE 1 — In the case of speeds higher than 15 mm/min, it is not necessary to vary the value of the measured quantity in the reverse direction as stated in **B-3.3**; it is sufficient that the sudden variation be carried out in the same direction immediately after 5 times the damping time. The total error for the point Y equal ε_y (*see* Fig. 3).

NOTE 2 — The recording obtained will be as shown in Fig. 2 and 3 below.

NOTE 3 — When it is found during the determination of intrinsic error that the measuring element has no hysteresis error, it is unnecessary to vary the measured quantity from the zero mark up to the upper limit of the effective range, a variation of 10 percent of the upper limit of the effective range above or below the selected value being sufficient to determine the total error.

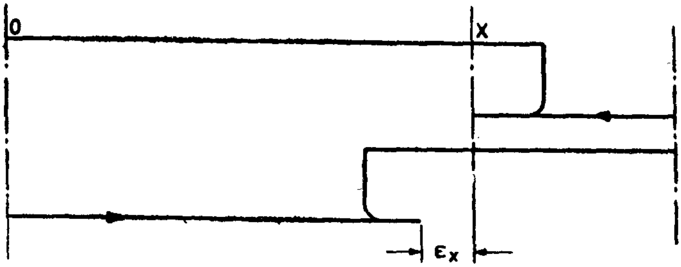


FIG. 2 DETERMINATION OF TOTAL ERROR (CHART SPEED 30 mm/h)

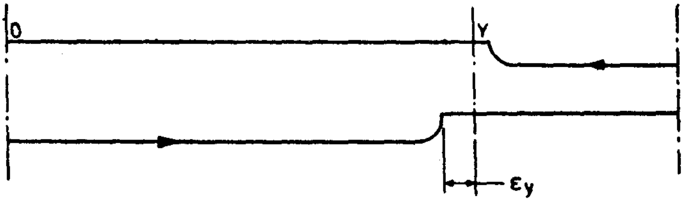


FIG. 3 DETERMINATION OF TOTAL ERROR (CHART SPEED 30 mm/min)

APPENDIX C

(*Clauses* 2.5.1 *and* 2.6.5)

FRICTION EFFECT OF ELECTRICAL MEASURING INSTRUMENTS OF THE DIRECT WRITING CONTINUOUS LINE RECORDING TYPE

C-1. INTRODUCTION

C-1.1 To indicate the level of accuracy of an electrical measuring instrument, the *class index* indicating the limit for the intrinsic error expressed as a percentage of the fiducial value has been adopted. In the simplest case, this is a percentage of the upper limit of the effective range.

C-2. INDICATING INSTRUMENTS

C-2.1 The reading of an indicating instrument depends not only on the value of the measured quantity and the intrinsic qualities of the instrument, but varies slightly and generally with a ' *reversible* ' *characteristics* as a function of other quantities, called *influence quantities,* such as temperature, position, external magnetic field, voltage (in the case of wattmeters), etc. Therefore, the ***intrinsic error*** shall be determined under ***reference conditions,*** that is, the influence quantities maintained at their reference values or within the values of their reference ranges.

C-2.2 The intrinsic error includes not only scale marking errors, but also the effects which occur in a random way, such as friction in the moving element, hysteresis, etc, which are generally small in the case of indicating instruments, and remain constant for a given value of the measured quantity after the pointer has come to rest. The class index indicates the limit for the intrinsic error expressed as a percentage.

C-2.3 The same class index gives also the limit of *variations* due to influence quantities expressed as a percentage in relation to the nominal range of use for each influence quantity. When an influence quantity is varied from its reference value (or from one of the limits of the reference range) to one of the limits of the stated nominal range of use, the variation resulting therefrom, expressed as a percentage, is given by the class index.

C-3. RECORDING INSTRUMENTS

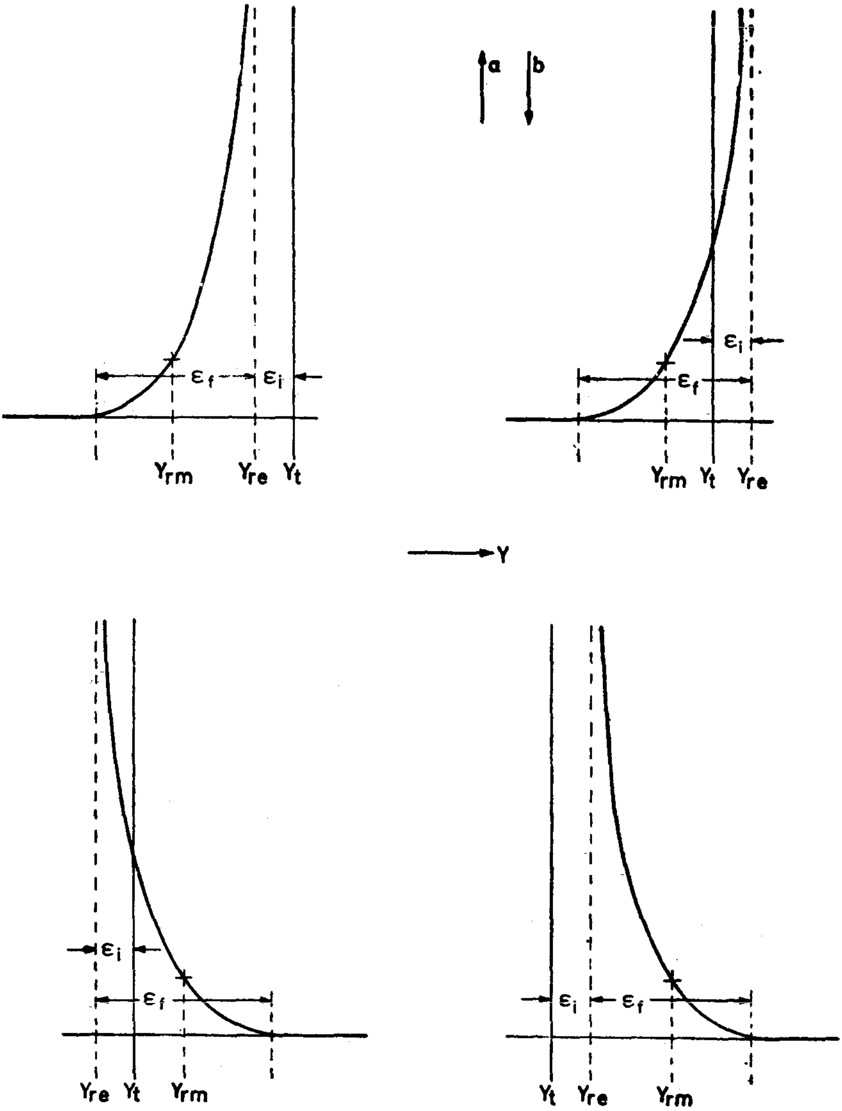
C-3.1 Continuous line recording instruments may show as a result of contact of the marking device with the chart surface a ***friction effect*** (as defined in **2.6.5**), the maximum value of which may not be negligible and may be comparable with the intrinsic error (as defined in **2.6.4.4**).

C-3.2 The friction effect, constituting a part of the total error in recording differs in its nature from the moving element friction (bearings), because its influence *decreases as a function of time* when the chart is moving, while the friction of the moving element remains constant with time. It will be clear that the friction effect is not analogous to variation due to an influence quantity.

C-3.3 It might seem obvious to determine the intrinsic error by including in it the maximum friction effect, which will occur under the most unfavourable conditions. But this method would not be in accordance with the idea of *intrinsic error* mentioned above (*see* **0.2**), as it is not intended that the intrinsic error shall include all influences which may occur in the most unfavourable conditions.

C-3.4 An analysis of friction effect shows that when the quantity to be measured is varied continuously and without overshoot, as far as a certain Y_t value, with the chart stationary, the latter being then set in motion, a trace is drawn having one of the forms shown in Fig. **4A**.

C-3.5 If, on the other hand, the quantity to be measured is varied linearly while the chart is in motion, the recorded trace will be analogous to that of Fig. 4B and comprises a straight section followed by a curve of the previous nature.

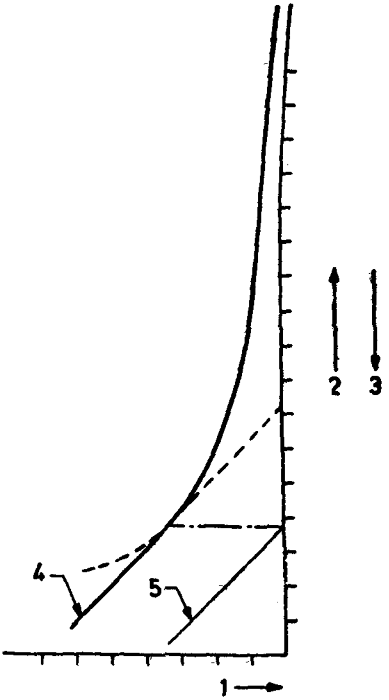


4A

Y_{re} Recorded value
Y_{rm} Momentary recorded value
Y_t True value
ε_f Maximum value of friction effect

ε_i Intrinsic error
a Time
b Chart travel
Y Measured quantity

FIG. 4 ANALYSIS OF FRICTION EFFECT — *Contd*



4B

1 Deflection of the marking device
2 Time
3 Chart travel
4 Trace of the marking device
5 True value

FIG. 4 ANALYSIS OF FRICTION EFFECT

C-3.6 It will be seen that the friction effect, the maximum value of which is represented by distance ε_f, decreases rapidly when the chart is in motion. The friction effect occurring in the recorded trace *in a given* moment is a friction of the maximum effect, which may practically vary between the limits 0 and 100 percent of ε_f and which depends on a large number of factors including:

a) maximum value of friction effect ε_f,

b) chart speed,

c) rate of variation of the measured quantity,

- d) time constant of measurement,
- e) damping factor of the instrument, and
- f) influence of vibration, etc.

C-3.7 This standard does not state any relation between the class index and the friction effect, and does not state limits to the latter. But the friction effect, expressed as a percentage of chart scale length, shall be smaller than a limit marked. If the limit may be expressed by the same figure as the class index, no separate marking is necessary.

C-3.8 This concept is in accordance with the principle that standard for recording instruments should run parallel to that for indicating instruments as far as possible, and that divergences, should occur only if justified by physical reasons. The friction effect dealt with here is quite different from other friction effects in indicating instruments.

The separate marking of the limits of intrinsic error and the limit of the friction effect gives as much information as possible to the user who may compare different instruments with respect to their accuracy and to the total error.

Under specified conditions of use, the total error may be obtained by the method given in Appendix B.

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